

FIBRES IN ASPHALT

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## ABSTRACT

The use of fibre materials as a key component of various types of hot mix products has been examined and utilized for over twenty years, but a much wider useage has been achieved in the last seven to ten years especially in the European countries.

This paper will discuss the overall use of fibres in both hot and cold mix as well as other specialty uses. The various types of fibres available for use in asphalt will be discussed as well as the mixes where they are most suitable. As with any additive being added to the conventional hot mix process, the use of fibres has its own unique problems in handling and effectiveness. These problems will be addressed with possible solutions along with the advantages that the fibres bring to the table. The major focus involving fibres will be on two of the most common type mixes which utilize fibres; Stone Matrix Asphalt (SMA) and Open Graded Mixes (OFC or OGFC).

With the implementation of the SHRP (Strategic Highway Research Program) for both asphalt binders and mix designs coming on stream the future use of fibres has tremendous potential for growth.

## INTRODUCTION

Fibre materials (cellulose, glass, mineral and synthetic) have been used in hot mixes throughout Europe for many years. Traditionally asbestos fibre has been the material of choice, but with the use of asbestos fibres being prohibited by law (due to health concerns) other fibre materials have been evaluated and substituted with very good results.

The implementation of the SHRP (Strategic Highway Research Program) for both asphalt binders and mix designs has led to the development of coarser graded mixes to combat pavement deformation and to give greater durability. This switch to the coarser graded hot mix designs has greatly improved the resistance to pavement deformation, but in doing so has created other problems (ravelling, shorter pavement life etc.) which have to be addressed. The use of fibres as an additive in the hot mix has helped in the solution of these problems.

## TYPES OF FIBRE

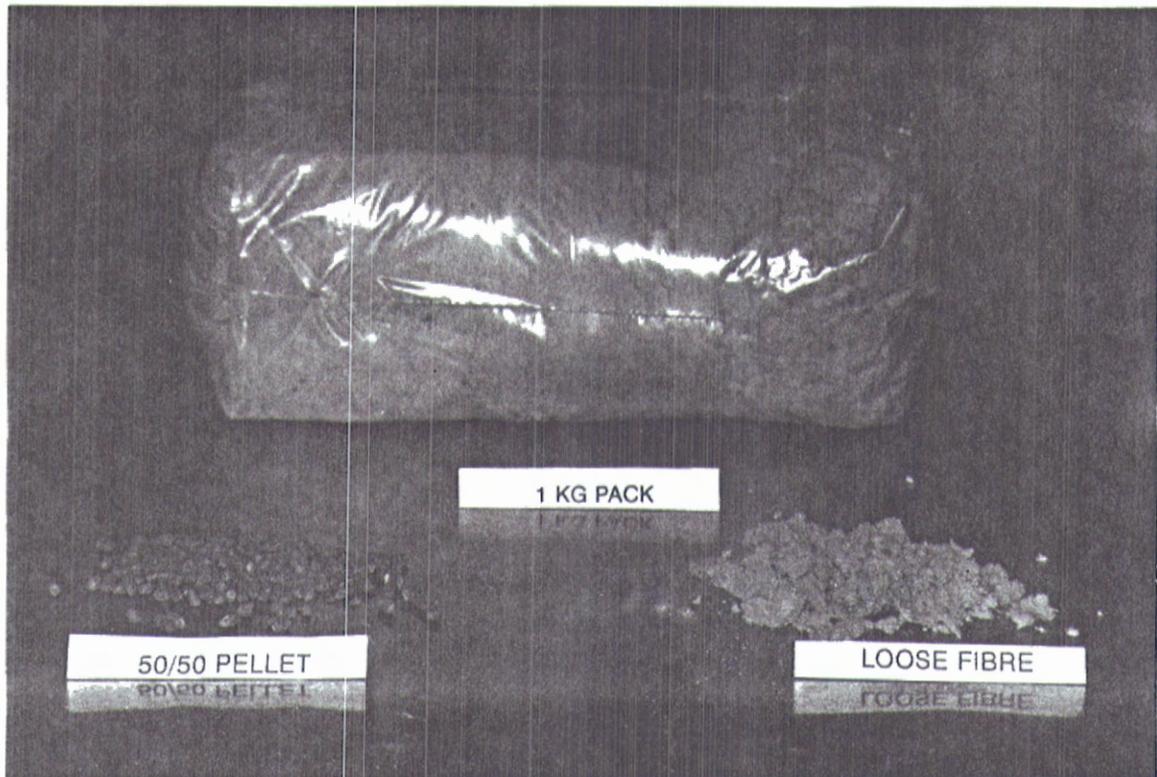
There are many different types of fibres but there are only four main ones which are utilized in asphalt products. These four types are as follows; cellulose, glass, mineral and synthetic.

### **Cellulose Fibre**

Cellulose is an organic compound which is frequently found in nature. The natural material is processed to remove the impurities resulting in a cellulosic material which typically consists of 75 to 80 percent cellulose with a pH measuring between 6.5 and 8.5. The cellulose fibre can be up to 5 mm in length but is usually 1 to 1.2 mm long with a thickness of approximately 40 to 45  $\mu\text{m}$ .

The cellulose fibres are packaged in sealed polyethylene packs with a significantly low melting point, which dissolves in the hot mix on addition. The size of the packs can be altered by the manufacturer (typically 1 kg to 5 kg) to suit the individual hot mix plant and batch size. There are also pre-coated fibres (pellet form) containing 50 percent fibres and 50 percent hard (40/50 penetration) asphalt. These pellet fibres are intended for use in drum mixer type hot mix plants (Photo 1).

There are a number of suppliers and the costs are typically in the neighbourhood of \$0.75 to \$1.00 per kilogram. The usual quantity used in hot mix is 0.3 percent by weight of fibre in a ton of mix.



PHOTOGRAPH 1: CELLULOSE TYPE FIBRE FOR DRUM AND BATCH PLANTS

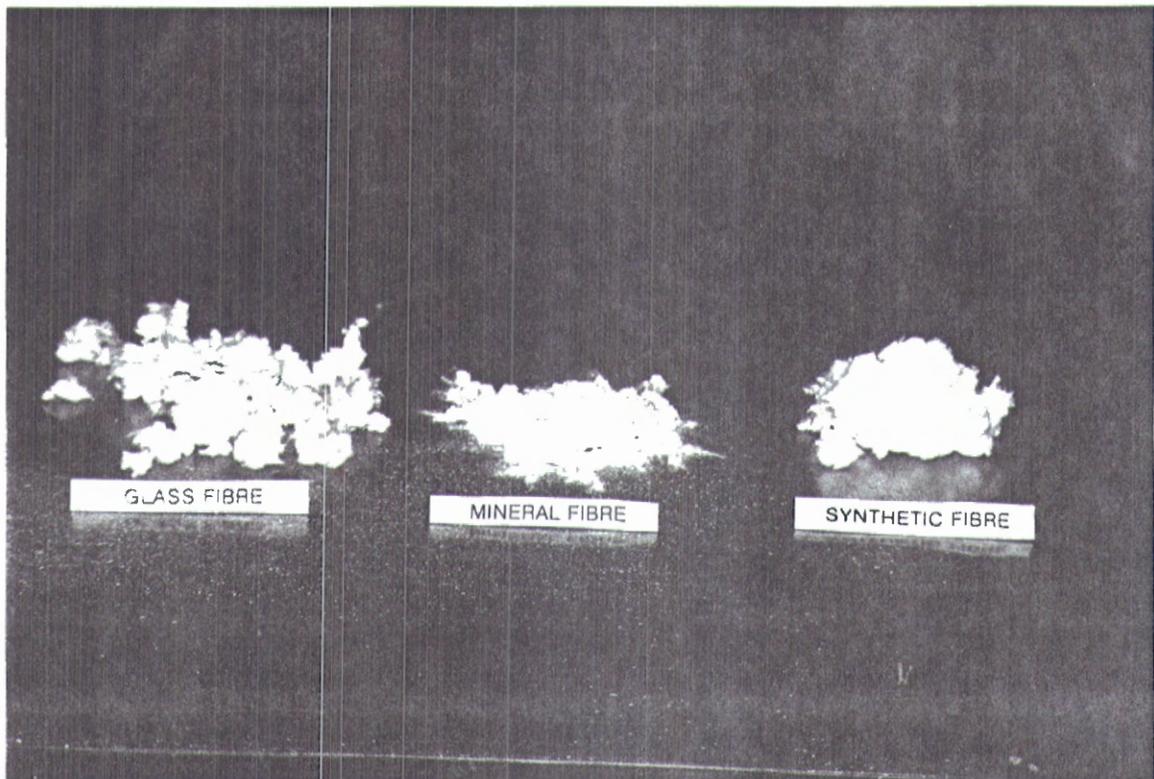
### **Glass Fibre**

Glass fibres are similar to the cellulose type fibres in length (1 to 5 mm) and shape and are typically 1 mm in length. The glass fibres can either be chemically treated or not. When chemically treated the fibres tend to be dispersed more easily and have better adhesive properties. The typical concentration level is 0.3 percent based on the total weight of mix (Photo 2).

There are a number of suppliers and the material is normally packaged in polymelt bags which dissolve very rapidly in the hot aggregate during the dry mix cycle of the hot mix process.

### **Mineral Fibre**

The mineral fibres are similar to the cellulose and glass fibres with comparable length (typically 1.0 mm). The mineral fibres are packaged in polymelt bags which can be varied in weight to suit the customer. The usual level of mineral fibre used in hot mix is in the range of 0.3 to 0.5 percent by total weight of mix (Photo 2).



PHOTOGRAPH 2: PHOTO OF GLASS, MINERAL AND SYNTHETIC FIBRE

### **Synthetic Fibre**

The two synthetic fibres most commonly used in the asphalt industry are polyester and polypropylene. Both products are polymerized with fractions from the distillation of crude oil. In order to serve as reinforcement for asphaltic materials the fibres should not melt, soften or lose their strength at elevated temperatures. Synthetic fibres are typically longer in length (1 to 13 mm) than the other fibre types, with lengths of normally 6 to 8 mm for hot mix (Photo 2).

The manufacturers of synthetic fibres can supply their fibre products in custom weighed polymelt bags to suit the individual hot mix plant. For hot mix a typical addition level of 0.3 percent is recommended [1].

### **USES FOR VARIOUS TYPES OF FIBRE**

The use of all four types of fibres is quite common in many different asphalt based products from hot mix to the specialty asphalt products like coatings. A general overview of fibre usage follows with the technical aspects of the fibres being discussed as well as their handling characteristics.

## Hot Mix

Originally the most commonly used fibre in all asphalt products was asbestos. Because of the health aspects the use of asbestos has been prohibited by law. This asbestos ban opened the door for the other fibre types to be evaluated with the result that now many of these fibres are being used in the industry.

The fibre most commonly being used in hot mix is the cellulose type. However the synthetic, glass and mineral fibres are being used as well. The mixes where these fibres are mostly being used are in Stone Mastic Asphalt (SMA), Open Friction Course (OFC) and Porous Asphalt (PA). The fibre content in these mixes is typically 0.3 percent by total weight of mix and are normally added into the dry mix cycle of the hot mix plant.

Synthetic type fibres have been used in conventional dense graded for a number of years. The polyester and polypropylene fibres tend to be longer in length, but the concentration level is still the same as for the other fibres at 0.3 percent.

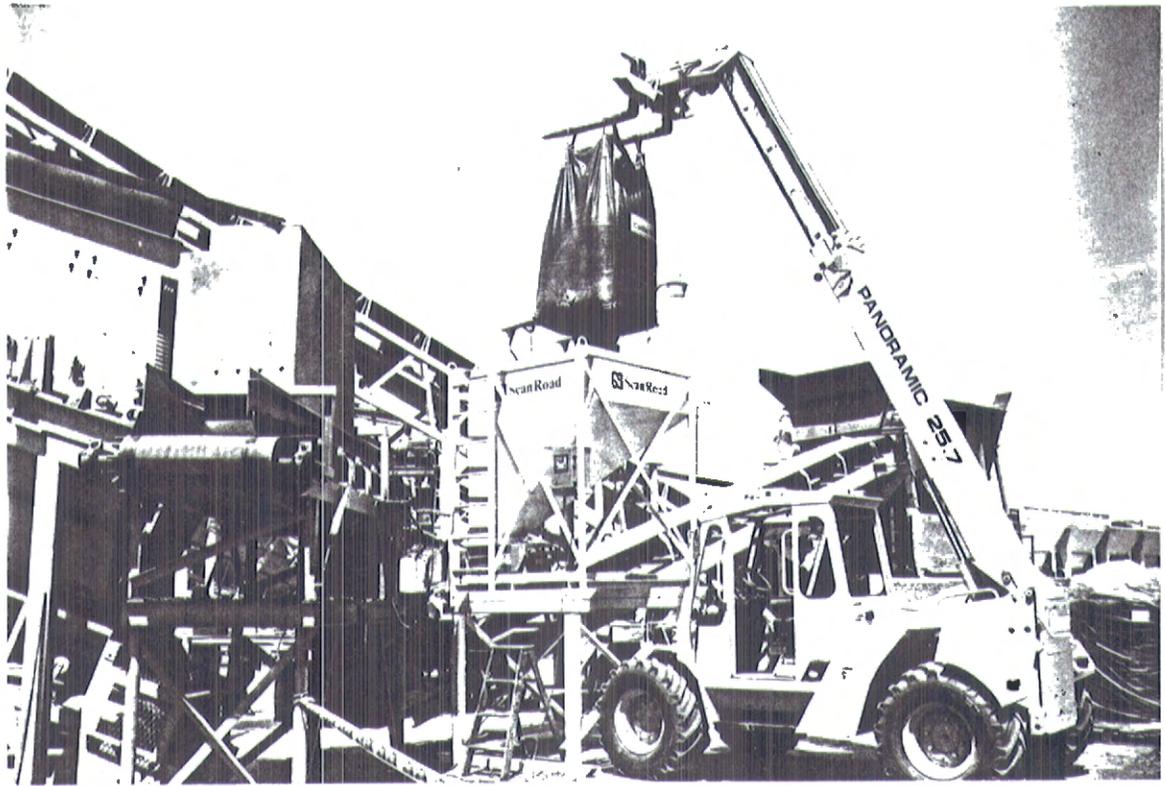
## Handling

There are a number of ways in which the fibres can be added to the hot mix. In a drum plant there are two methods of incorporating the fibre into the mix.

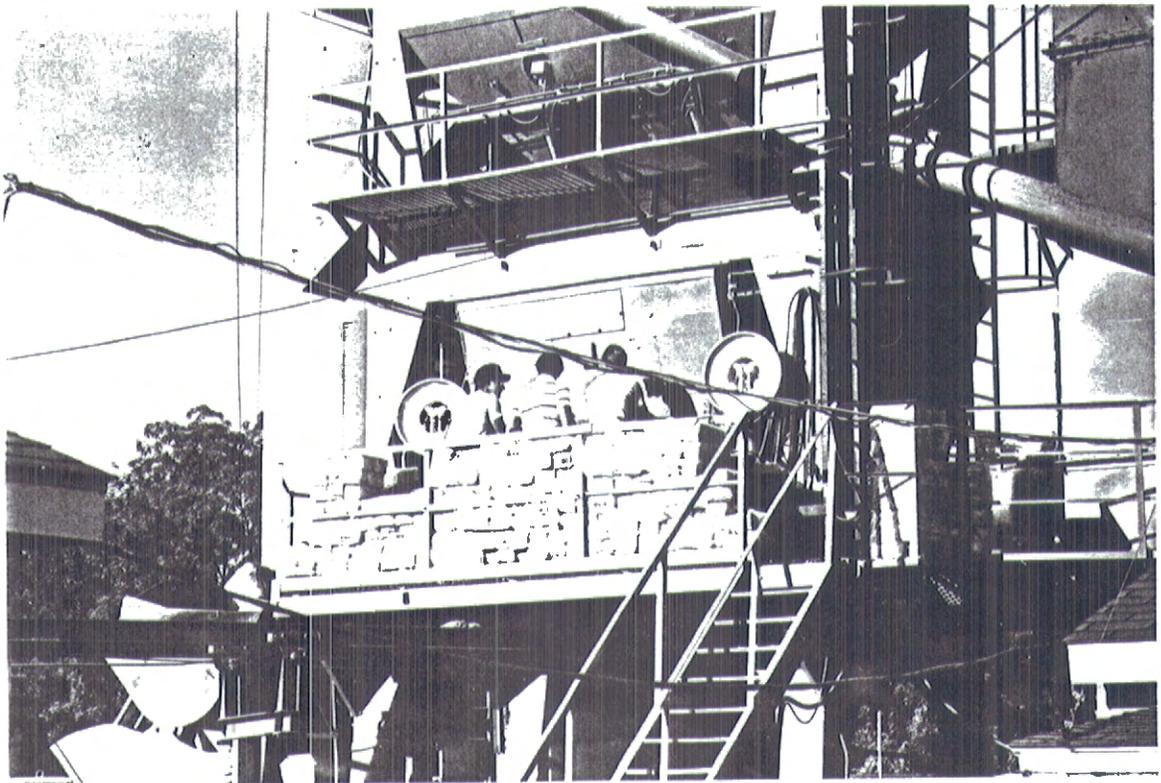
A number of fibre manufacturers have developed feeder/blower systems which deliver the fibre at a metered rate consistent with the production rate designated by the plant. There has been some questions raised about the accuracy of this method as the fibre material is airborne inside the drum which could result in some of the airborne fibre being removed through the dust collector system and not being returned to the mix. One fibre supplier, to address this problem blows the fibre into the asphalt cement stream within the drum. This traps the fibre in the asphalt cement and prevents it from being removed. Another manufacturer uses a pellet type cellulose fibre (approximately 50/50 asphalt and fibre). The pellets are fed through a hopper system in the required quantity to the reclaimed asphalt pavement (RAP) conveyer belt into the drum (Photo 3) [2].

The batch plant system incorporates the use of the polymelt bags of fibre. The proper number of bags (custom weighed) are added with the hot aggregate drop. The fibre bags can be added through the pugmill access door, onto the fill weigh hopper, or through a port in an unused hot aggregate bin (Photo 4). Some plants have installed a chute to simplify and to speed up handling.

The batch plant operation is labour intensive (2-3 people) to physically add the fibre to the pug. This results in an increase in the cost per ton not including the cost of the fibre. In working with the polymelt bag system the aggregate temperature has to be



PHOTOGRAPH 3: CELLULOSE PELLET SYSTEM IN OPERATION



PHOTOGRAPH 4: BATCH PLANT PROCESS FOR FIBRE ADDITION

high enough to ensure complete melting of the polymelt bag into the mix in order to release the fibre early enough to allow all the fibres to be dispersed uniformly throughout the batch (Photo 5). The bags are compressed very tightly and it takes time for the dispersion to occur. Typically there is an increase in the dry mixing cycle of 10 to 15 seconds to accommodate the fibre addition with no extra time added for the wet mixing cycle [3]. This extra time required for the mixing process slows the hourly production rate, which in turn adds extra cost to the product.

The SMA, OFC and PA mixes are easier to place and compact than conventional mixes, especially in thin lifts. These mixes are less sensitive to laying failure with respect to segregation and draindown of the asphalt cement during hauling, placing and compacting.

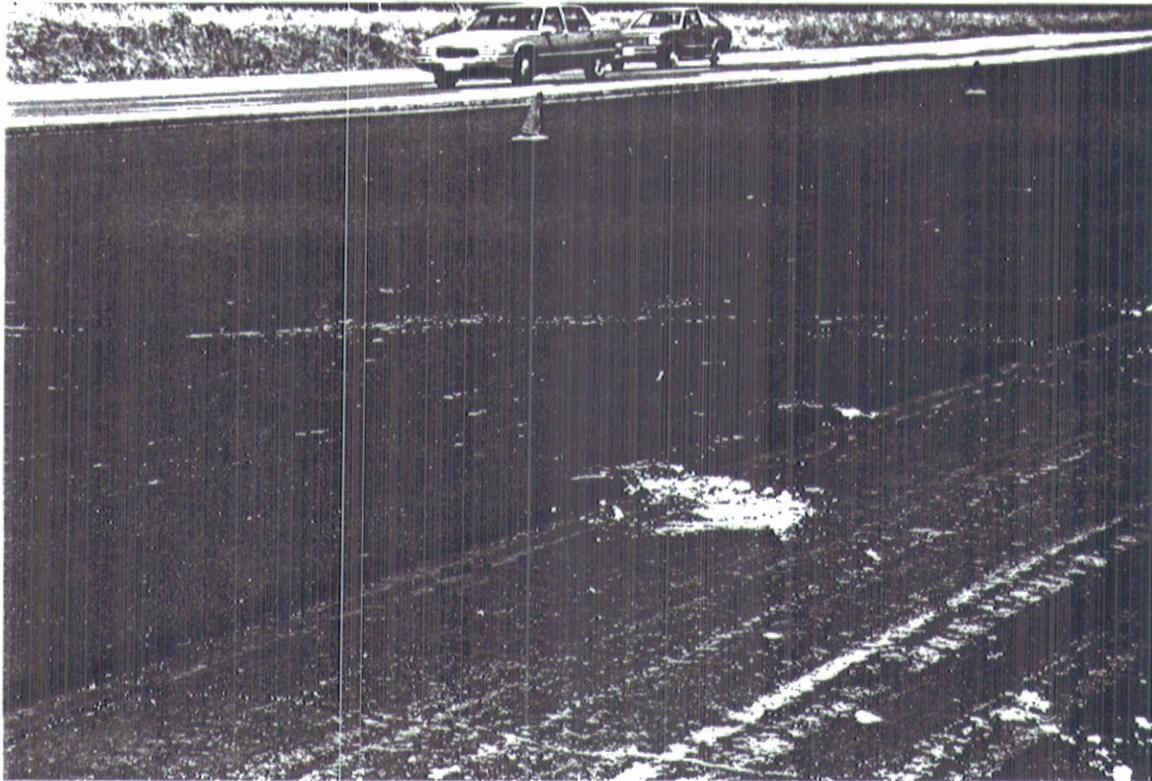


Figure 5: LOW TEMPERATURES CAUSE IMPROPER FIBRE DISPERSION

#### Advantages in the Use of Fibres in Hot Mix

There are a number of advantages when incorporating fibres into hot mixes such as SMA, OFC and Porous Asphalt (PA). Table 1 shows a comparison of SMA and PA properties and features with those of

conventional hot mix (HMA), which is based on Nordic experience. The highlighted properties and features can be directly attributed to the use of fibres in the mix. The addition of fibres prevents the draindown of asphalt cement in both OFC and Porous asphalt [5]. Fibres not only prevent the flow of asphalt cement to the bottom of the layer (preventing ravelling and premature failure of the mix) but also allow for the addition of more asphalt cement (partially

Table 1: Ranking of Stone Mastic Asphalt (SMA) and Porous Asphalt (PA) Compared with Hot Mix Asphalt (HMA)[a]

Property or Feature	Ranking Compared to HMA [b]	
	SMA	PA
Shear Resistance	2	2
Abrasion Resistance	2	-½
Durability	2	-1½
Load Distribution	-½	-1½
Cracking Resistance	1½	-½
Skid Resistance	1	1½
Water Spray	0	3
Light Reflection	1	1½
Noise Reduction	0	3
Public Recognition	2	3

a. Adapted from ranking by Nordic asphalt technologists given in Report on the 1990 European Asphalt Study Tour (East) [4]

b. Ranking Scale:

0	Equal		
1	Better	-1	Worse
2	Much Better	-2	Much Worse
3	Very Much Better		

but also allow for the addition of more asphalt cement (partially to coat the fibre). This addition of more asphalt cement (range of 0.3 to 1.0% extra) leads to a more durable pavement (increased service life) but also to improved low temperature cracking [6,7]. The fibres hold coarser mixes together for more uniform laydown and

help to prevent segregation. The porous mixes are especially susceptible to ravelling and the addition of extra asphalt cement, due to the fibre addition, holds these mixes together [8].

As with any process there are some drawbacks to the use of fibres. The immediate disadvantage is the higher costs to produce the mix (in the case of batch plants there is a lower production rate) as well as the extra requirements for fibre; extra manpower involved in adding the fibre (in the case of a batch plant); extra equipment in a drum plant (feeder/blower gear or hopper system); and the extra amount of asphalt cement required because of the fibre addition to the mix. Other than the fixed costs for equipment the price per tonne of mix could be in the range of 20 to 30 percent higher once an operator is fully established and the paving contracts tendered have a significant amount of tonnage.

### **Cold Mix**

Synthetic fibres have been used in cold mix patching material (0.3% polypropylene or polyester by total weight of mix) for more than ten years to give improved properties to the mix. Synthetic fibres have been added to both cutback and emulsion stockpile patching material.

The addition of synthetic fibres to cold patch material makes the material more flexible and easier to compact, which aids in the prevention of shoving and ravelling. The function of the fibres is to improve the adhesive and cohesive strength of the cured asphalt matrix, thereby increasing the retention of the patching material. The cold patch material is used in the repair of potholes on highways and parking lots, and can be used on concrete structures as well as asphaltic concrete.

### **Crack Sealants**

Fibres are used in both hot-pour (asphalt cement plus fibres) and cold pour crack sealants (blends of asphalt emulsion, mineral filler, chemicals and latex emulsion plus fibres).

Synthetic fibres such as polypropylene and polyester are used in hot-pour sealants typically in concentration levels of 5 to 8 percent of the total weight of asphalt cement. The fibres provide improved asphalt cohesion and adhesion as well as strength.

In the past the rubberized cold-pour crack fillers used to incorporate asbestos fibres but due to the health effects associated with asbestos the industry has switched to cellulose type fibres. The fibres (typically 1.5 to 2%) in conjunction with the mineral fillers give the sealer body and flow combined with good tensile strength and adhesive properties.

## Coatings

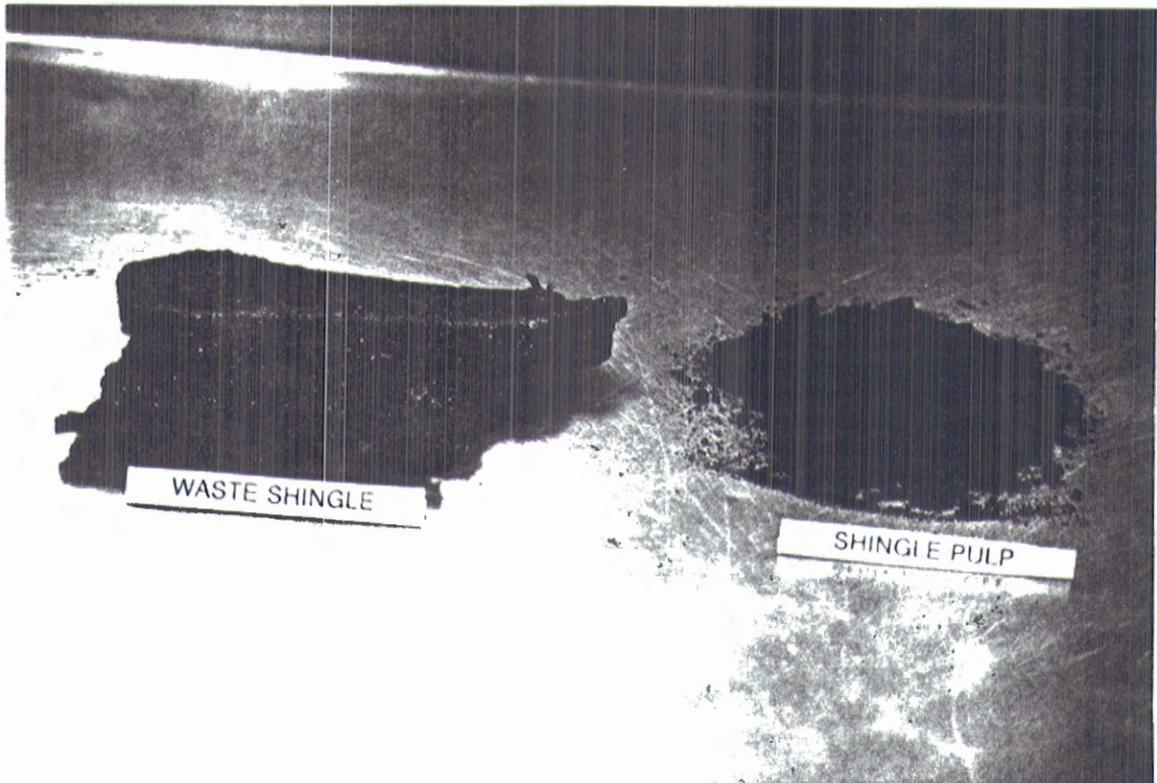
As with the crack sealants the cellulose type fibres are used as a replacement for asbestos. The coatings cover the range from emulsion based sealers to the various cutback type coating products.

Emulsion based sealers such as driveway sealers and tennis court cushion coats utilize the cellulose fibre to provide fast and thorough drying, give good rheological properties to create a level surface.

Cutback type coatings such as roof coatings (aluminum and black), foundation coatings (concrete) and undercoatings (automobile) use the cellulose fibre in various quantities (typically from 2 to 5 percent) to provide sag resistance and allow the products to be trowelled without dripping.

## FIBRE RECYCLING

In North America it is estimated that 500,000 tons of roofing shingle waste is generated annually in addition to the reroof material from rebuilding of shingle and built-up roofs, which amounts to millions of tons annually. Disposal of this waste is usually accomplished by placing in landfills.



PHOTOGRAPH 6:

SHINGLES BEFORE AND AFTER PROCESSING

Asphalt roofing shingles contain approximately 35 percent asphalt 45 percent aggregate and 20 percent mineral filler. The presence of the fibres in this waste material makes it attractive for use in hot mix products such as SMA or OFC mixes as well as conventional dense graded hot mix.

The ideal shingle material to use is the trimmings from shingle production as they are the most uniform in composition. The trimmings are processed into a pulp like state (Photo 6) and stockpiled for future use. The processed shingle waste is added to the mix by using the RAP feeder directly into the weigh hopper on a batch plant. The mixes utilizing this shingle waste are designed to incorporate from 5 to 10 percent of the waste shingles. The composition of the shingle waste provide the mix with the benefits of fibre (fibreglass or cellulose), the additional asphalt cement and a good quality fine aggregate (usually traprock).

Work done in the Province of Ontario in the past year using shingle waste has been with conventional hot mix. Mixes have also be placed using a combination of shingle waste and reclaimed asphalt pavement (RAP). Preliminary test results indicate that this type of recycling can be very beneficial and plans are being made to place trial sections of SMA incorporating waste shingles during the 1994 construction season.

#### FUTURE USAGE OF FIBRES

With the implementation of the SHRP (Strategic Highway Research Program) for asphalt binders and mix designs coming on stream in the next few years there is potential growth in the use of all fibre types.

Data obtained from SHRP and other research programs indicates that mixes such as SMA, OFC and porous asphalt will be required to combat permanent deformation (rutting), skid resistance and traffic noise. Because of increased traffic volumes and the types of vehicles (bigger loads) now on the major highways and city streets these mixes will become the way of the future. Since fibres are one of the basic components of these mix types the projection is for a definite increase in fibre demand over the next ten to twenty years.

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